

Edition 4.2 EBAF: Surface

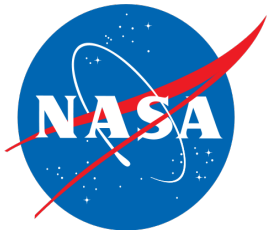
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CERES Science Team Meeting
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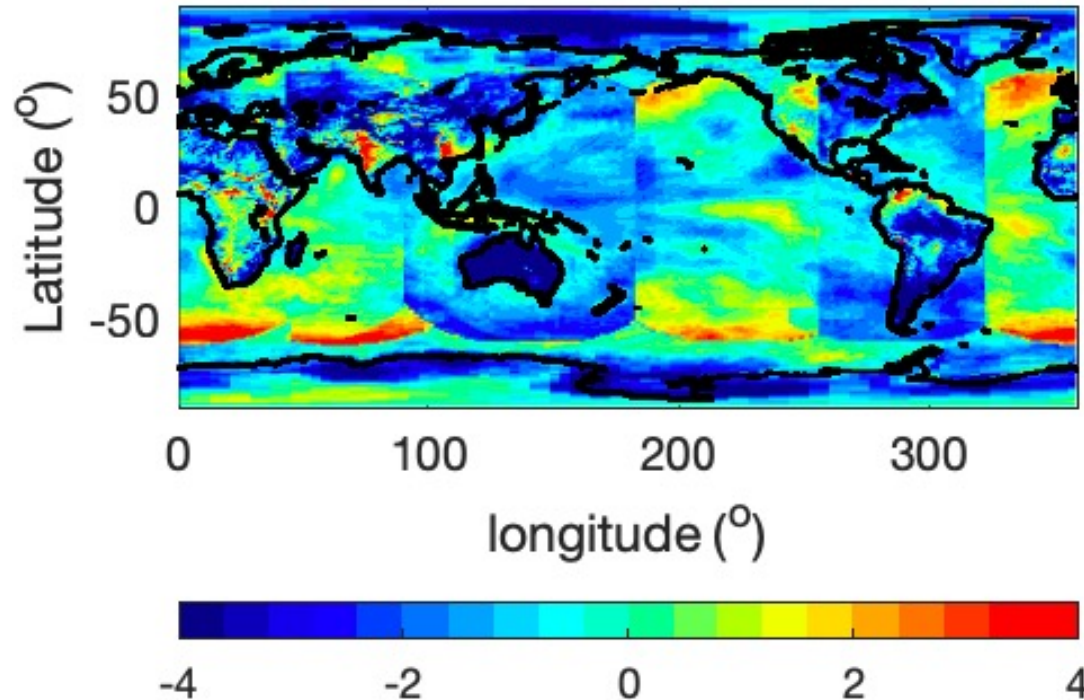
Outline of this talk

- Difference between Edition 4.1 and 4.2
 - noGEO SYN
 - Diurnal cycle
- Edition 4.2 production process
- Preliminary results of surface radiative flux change

Issues in surface irradiances from Edition 4.1 EBAF

- Regional longwave irradiance trends are influenced by GEO artifacts
- Are cloud properties derived from geostationary satellites needed for detecting surface irradiance change?

Regional trend of net longwave irradiance in $\text{Wm}^{-2} \text{dec}^{-1}$



Time period:
March 2000 through January 2020:
Climatology period:
July 2002 through June 2007

Two underlying assumptions in producing noGEO EBAF

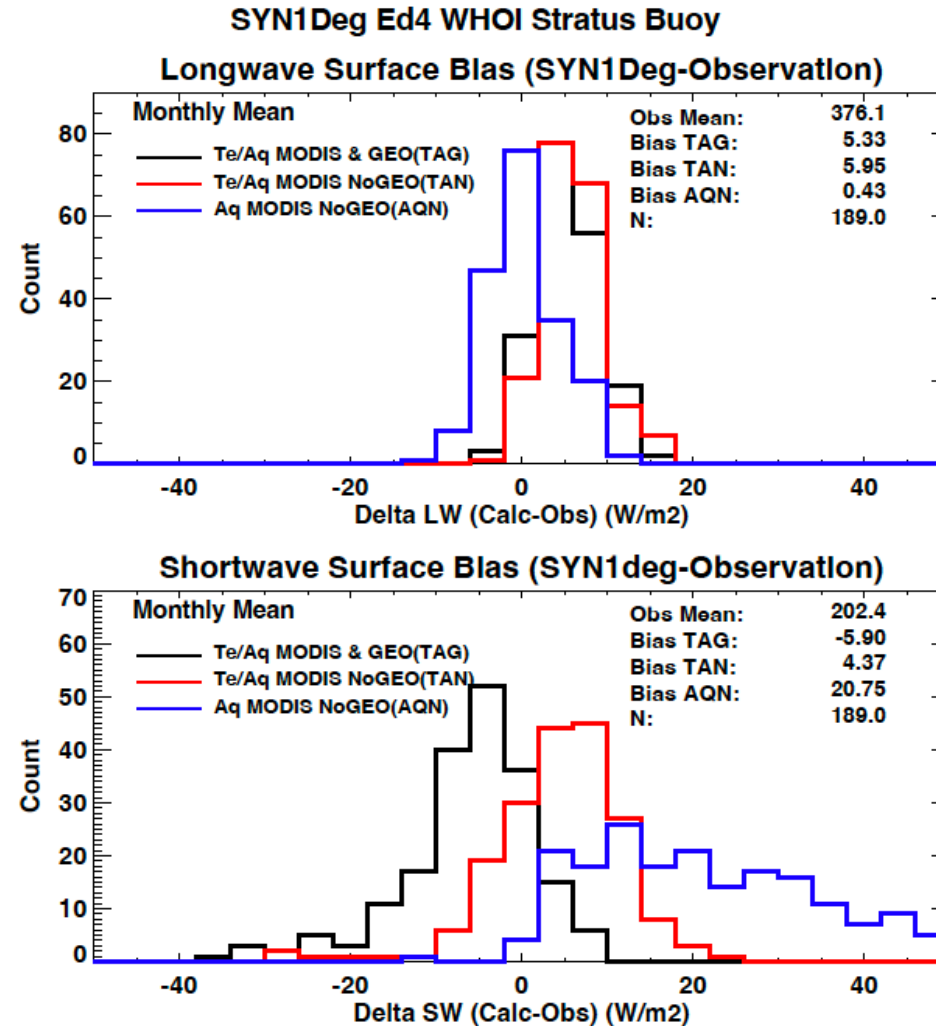
Basing concept of noGEO EBAF is that TOA and surface irradiances consist of climatological mean and anomalies. The difference of irradiances derived from Terra, Terra+Aqua and NOAA20 is caused by the difference in climatological means.

Assumptions are:

- 1) Terra+Aqua noGEO provides correct regional monthly mean surface irradiance (4 times day+night, 2 times daytime, per day observations provide diurnal cycle of clouds).
- 2) noGEO (Terra only, Terra+Aqua, and NOAA20) provides correct anomaly variabilities.

Comparison with surface observations

Monthly mean flux difference



— Terra+Aqua+GEO

— Terra+Aqua noGEO

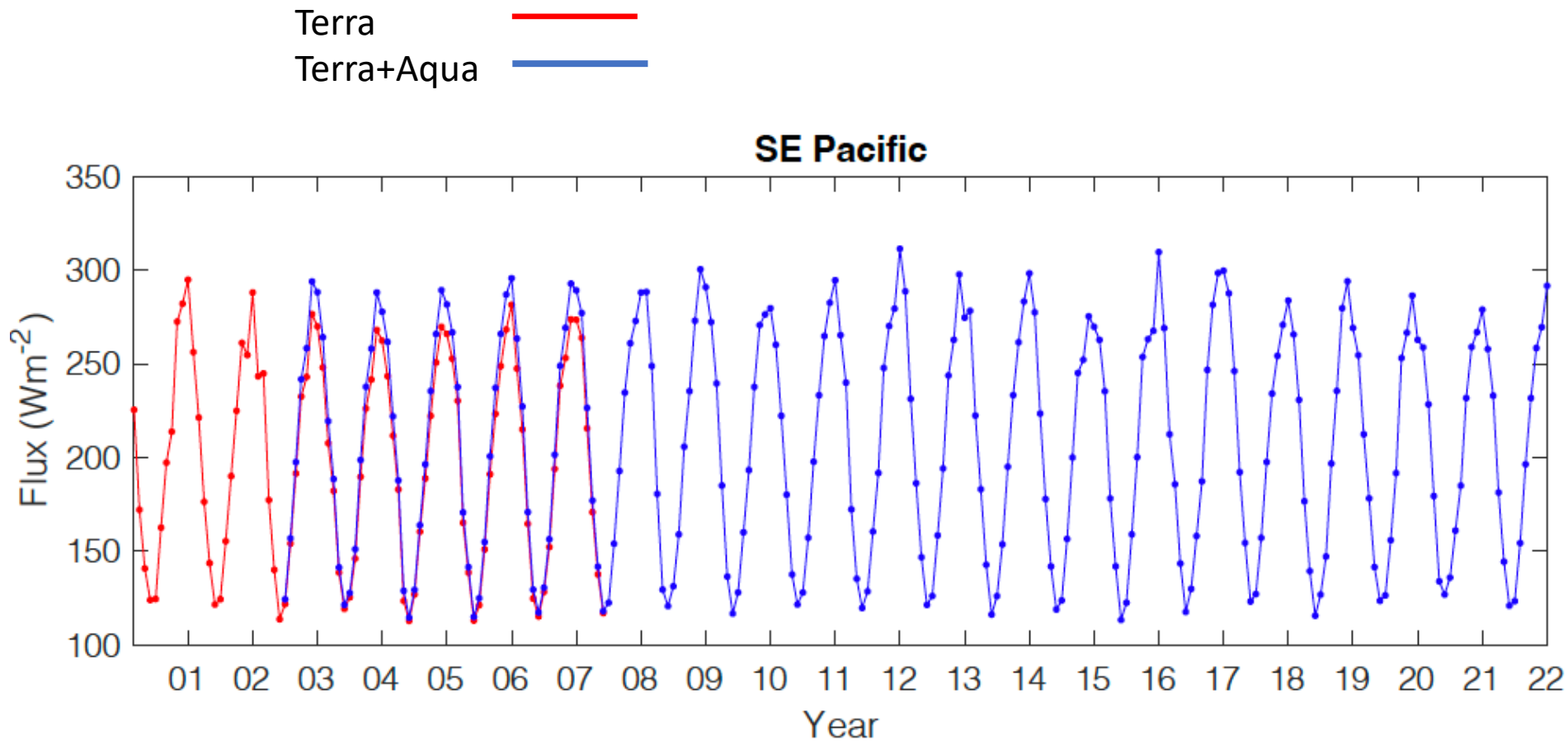
— Aqua noGEO

Terra+Aqua noGEO clouds are sufficient to produce monthly mean

Observing surface radiation budget change

- Combining surface shortwave flux anomalies derived from Terra and terra+Aqua

Downward surface all-sky shortwave irradiance

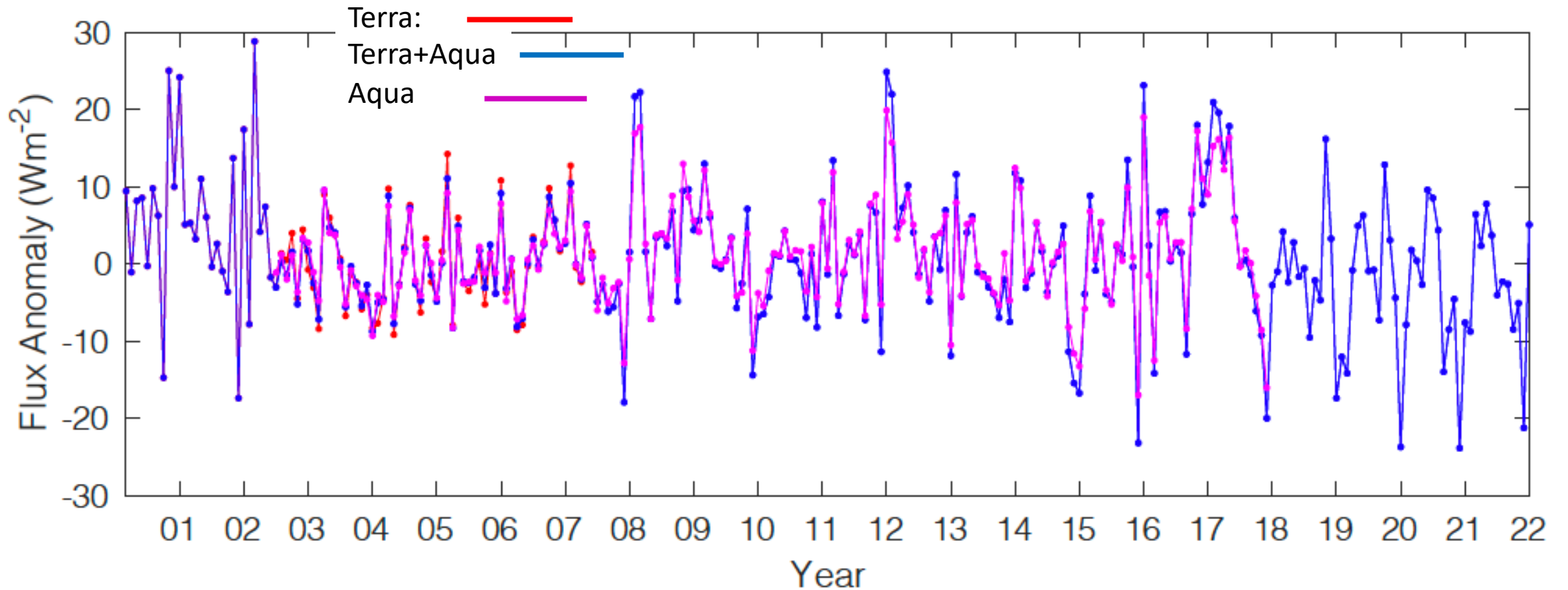


Separate flux into
Climatological mean
Anomalies

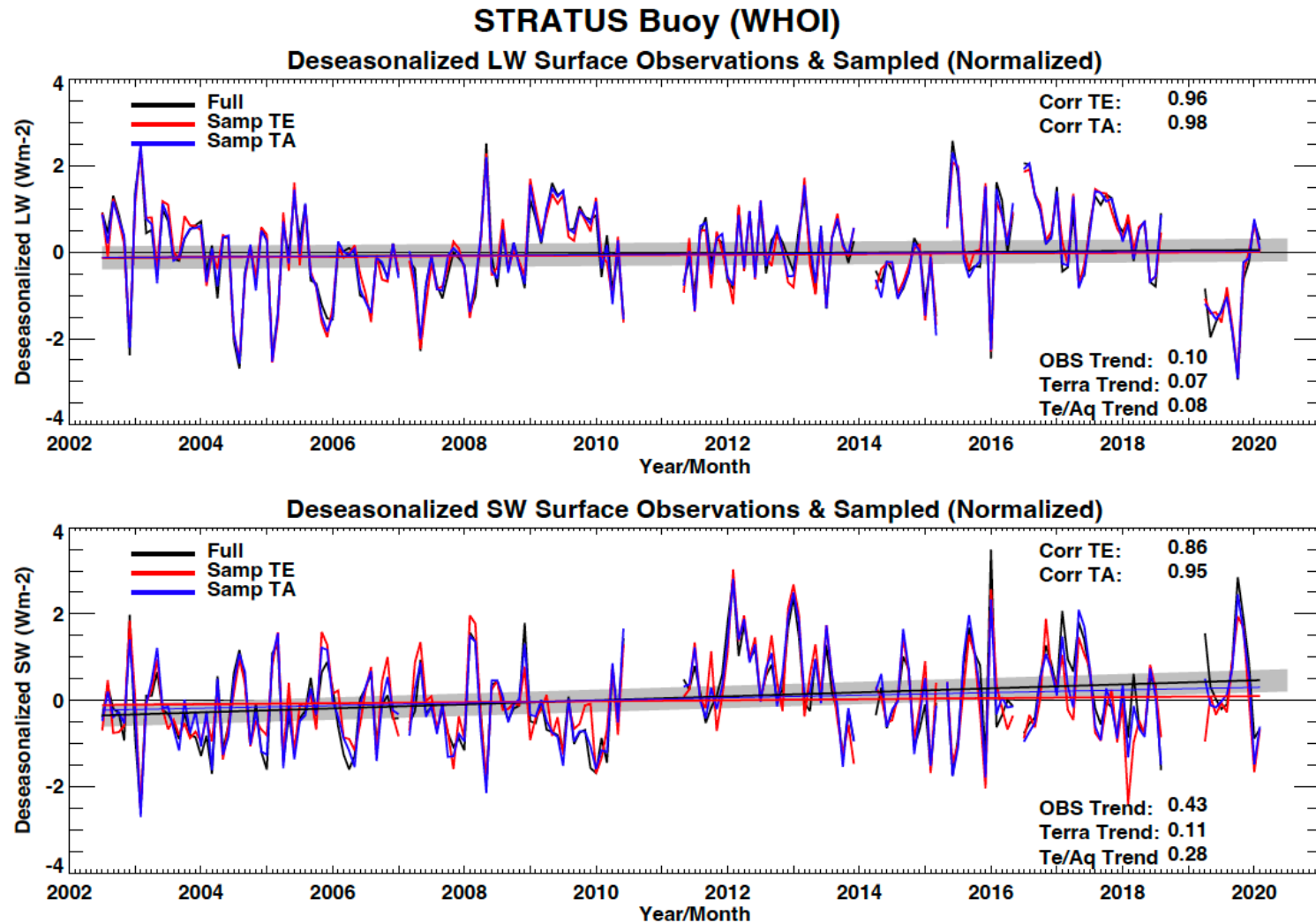
Terra only climatological
mean is adjusted to
match Terra+Aqua
climatological mean

Anomaly time series, Terra, Terra+Aqua, Aqua

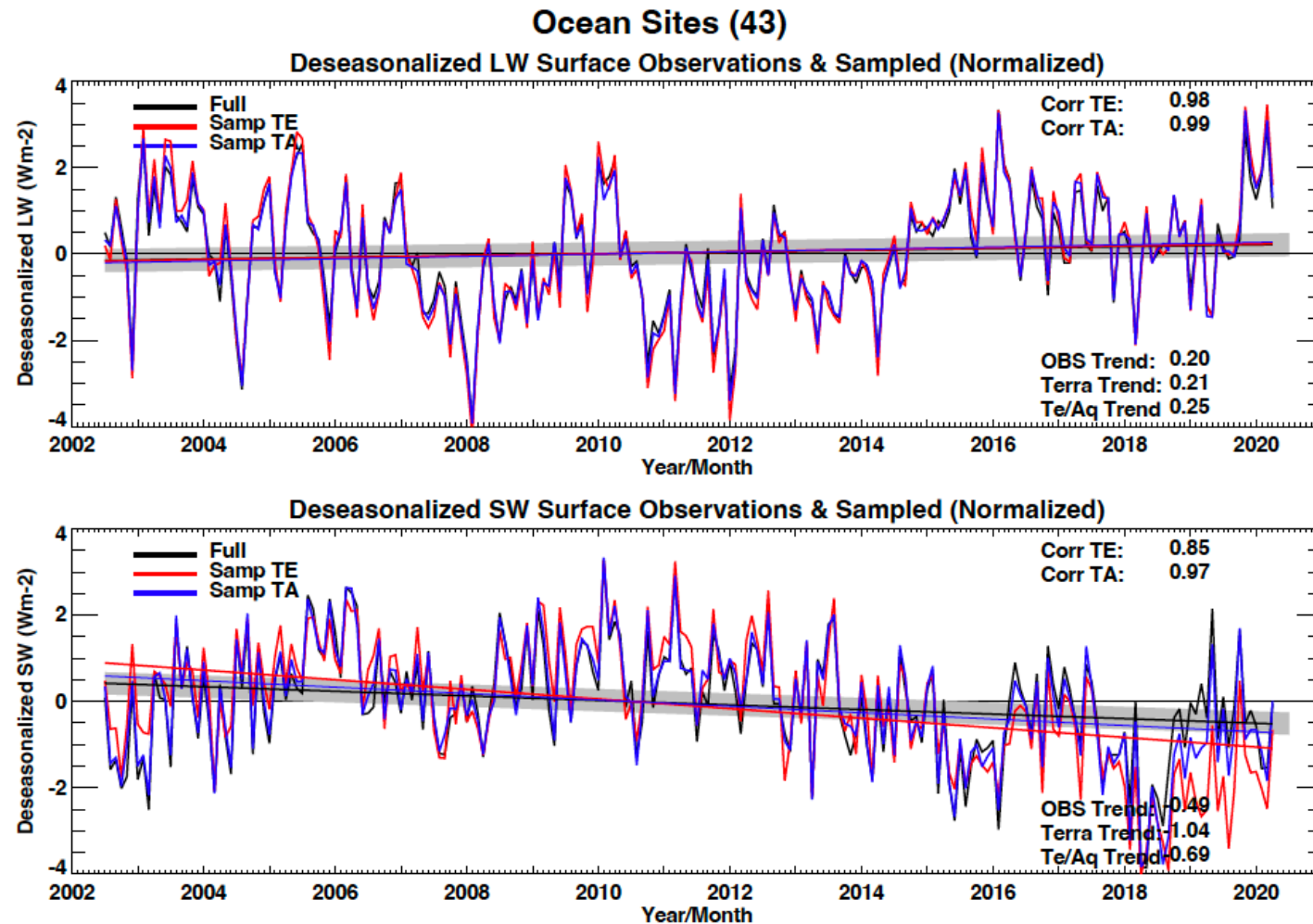
Downward shortwave irradiance anomaly timeseries over southeastern Pacific



Anomaly timeseries from surface observations



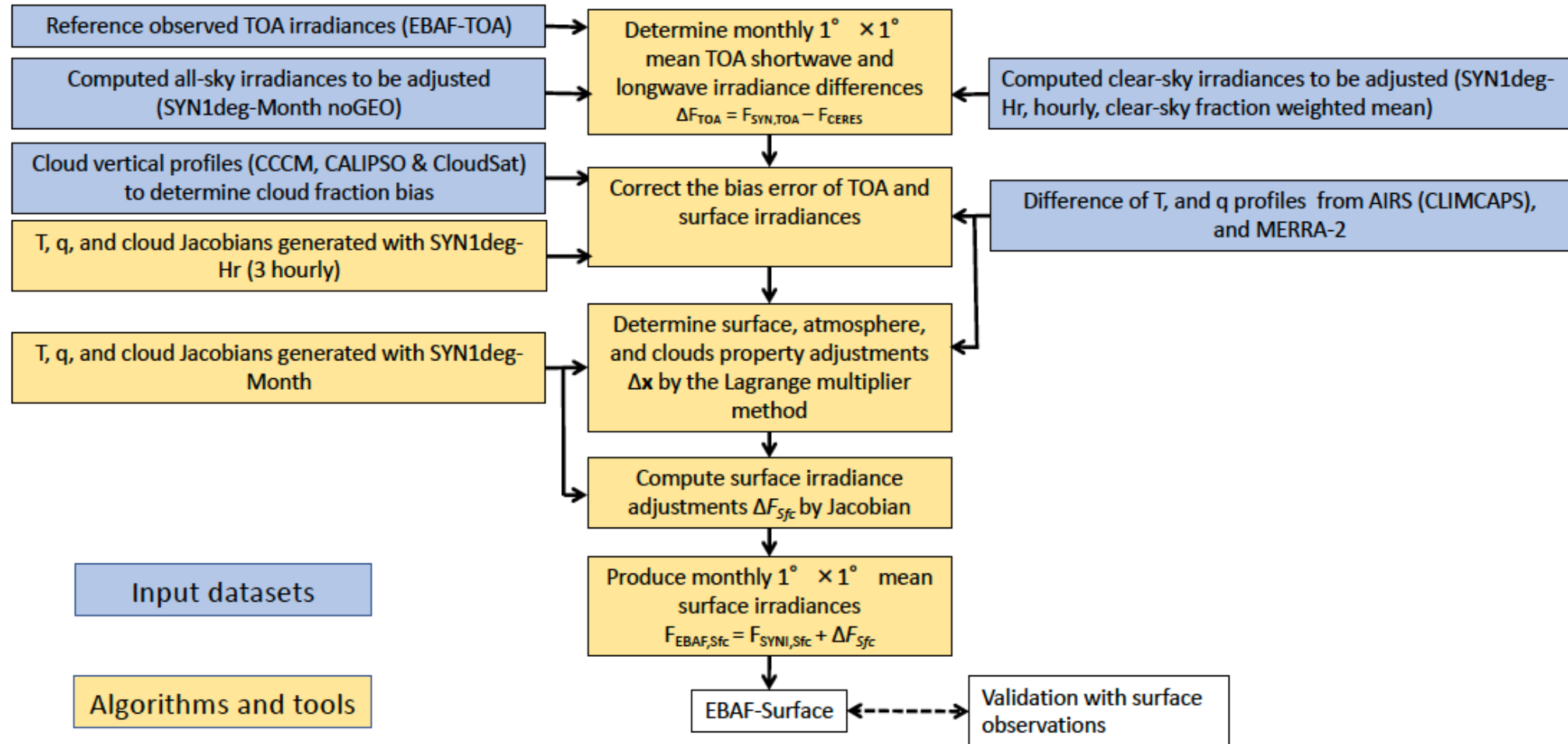
Anomaly timeseries from surface observations over ocean



Edition 4.2 EBAF process (surface irradiances)

- Based on noGEO SYN (hourly surface irradiances)
- Bias correction of upper tropospheric (200 hPa to 500 hPa) temperature and humidity is based on MERRA-2 and AIRS L3 (CLIMCAPS) differences
 - Revision of radiative kernel is TBD
- Cloud fraction correction is based on MODIS and CALIPSO/CloudSat difference (total cloud fraction exposed to space and low-level cloud fraction viewed from the surface)
- Radiative kernels used for bias correction and Lagrange multiplier are produced with MODIS clouds and MERRA-2
- Climatological for Terra only and NOAA-20 only periods are adjusted to match Terra+Aqua climatology (5-year overlap periods)
- Temperature and humidity diurnal cycle (MERRA-2), and solar zenith angle change are considered (hourly). Only missing diurnal cycle is cloud diurnal cycle.

Edition 4.2 process flow diagram



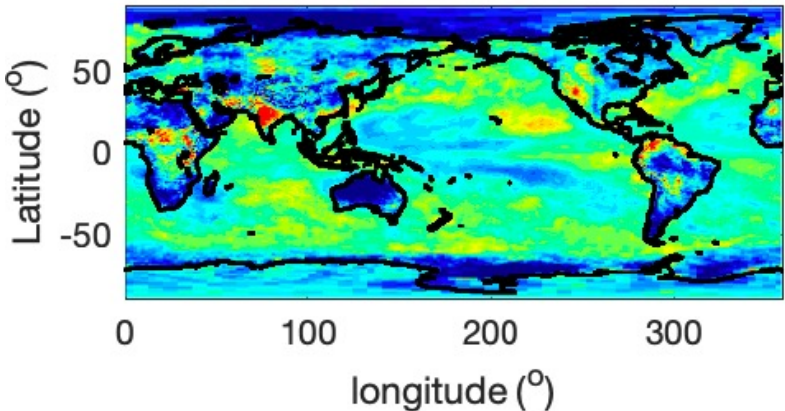
Regional net longwave irradiance trend ($\text{Wm}^{-2} \text{dec}^{-1}$)

Time period: March 2000 through January 2020:

Climatology period: July 2002 through June 2007

EBAF 4.1 with GEO and GEOS-5.4.1

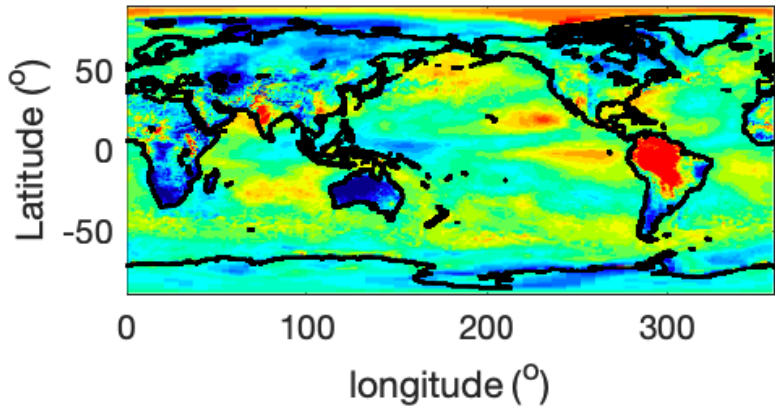
Clear-sky



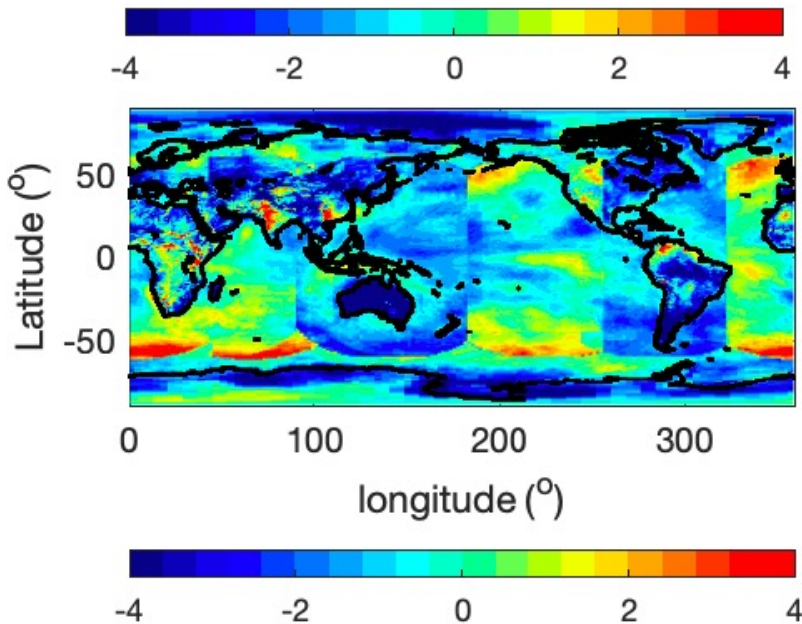
GEOS5.4.1 vs.
MERRA-2

SYN NoGEO and MERRA-2

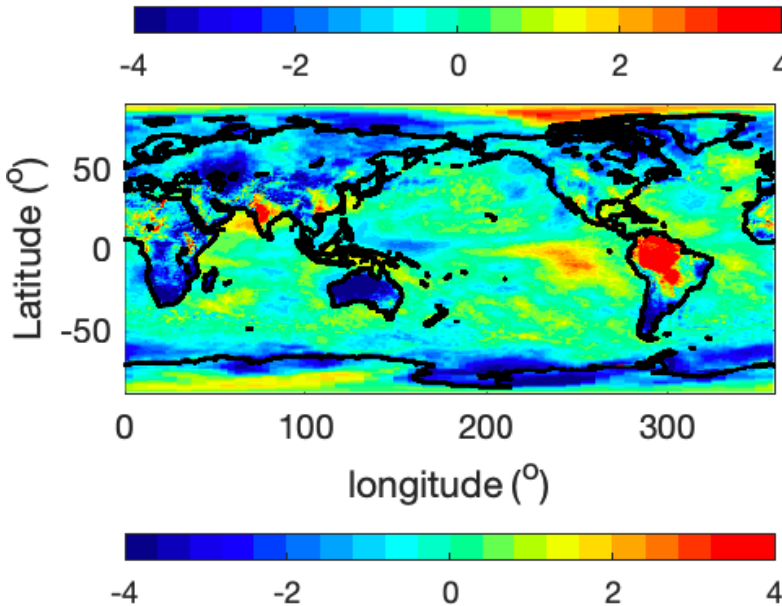
Clear-sky



All-sky



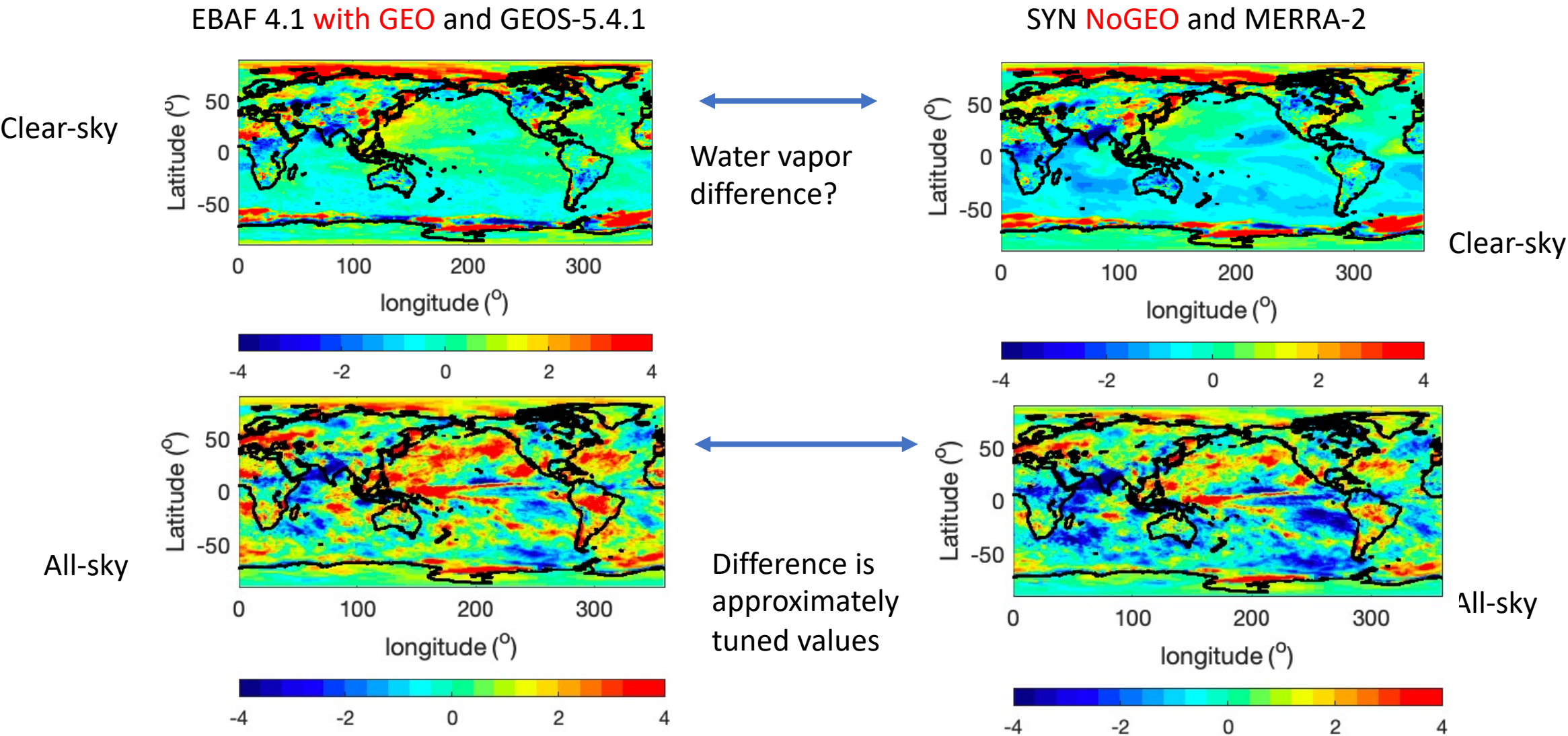
All-sky



Regional net shortwave irradiance trend (Wm⁻² dec⁻¹)

Time period: March 2000 through January 2020:

Climatology period: July 2002 through June 2007



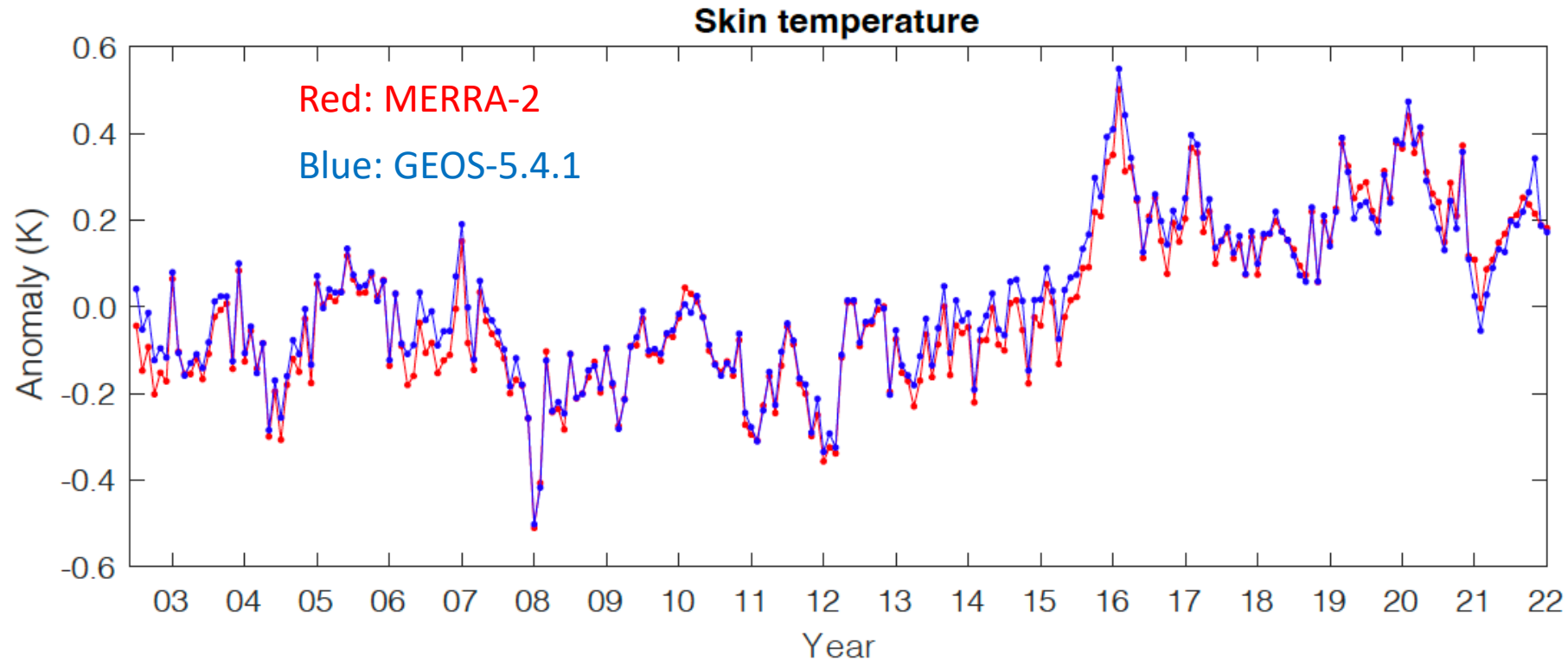
Summary and conclusions

- EBAF 4.2 uses Terra, Aqua, and VIIRS derived cloud properties and no geostationary satellites derived cloud properties (i.e. no GEO artifacts)
- Surface irradiances are computed hourly.
- Terra + Aqua cloud properties and cloud properties interpolated between their overpass time are sufficient for regional monthly mean surface irradiance.
- Terra only and NOAA 20 only derived cloud properties merged into Terra+Aqua time series are sufficient to derived anomaly time series of surface irradiances.
- Edition 4.2 EBAF-surface will be released by the end of this year.

Back-ups

GEOS-5.4.1 and MERRA-2 differences

Global mean skin temperature anomalies

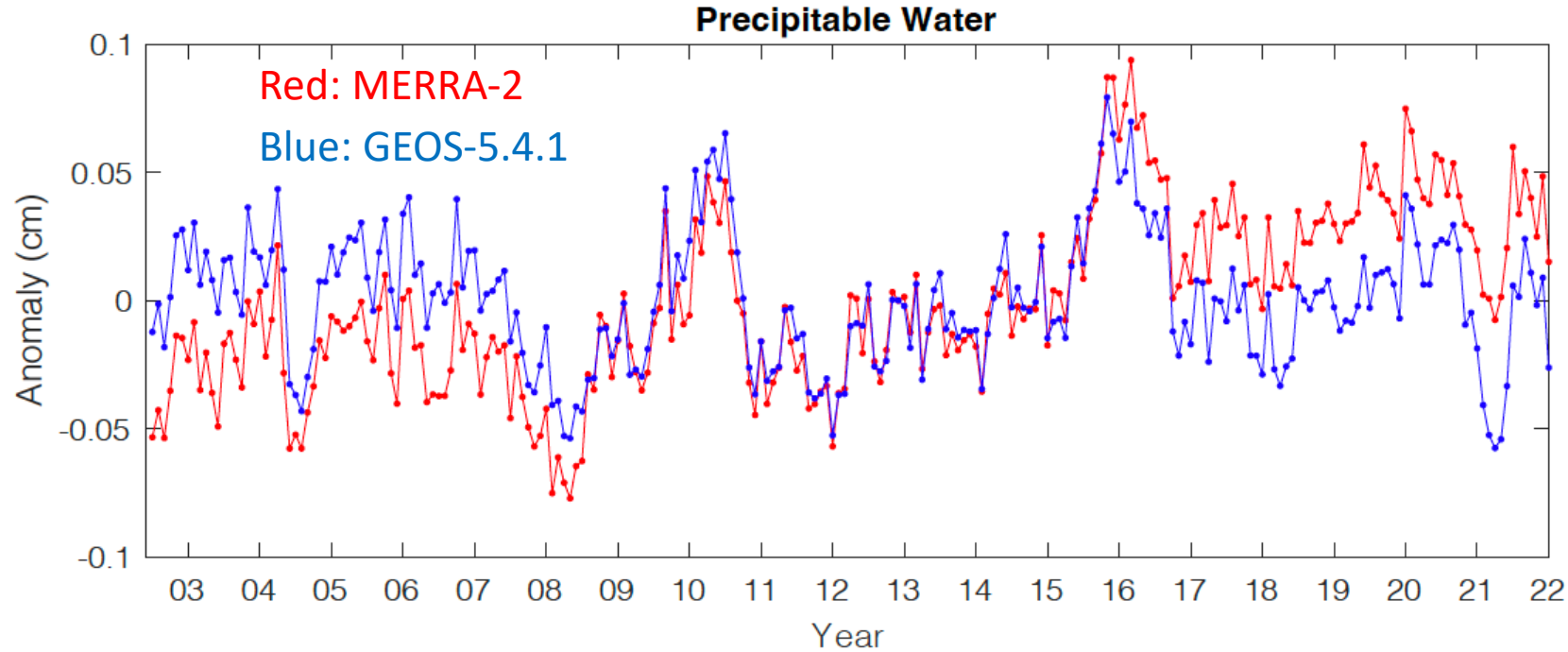


Global mean skin temperature in the post hiatus period (after July 2014) is 0.29 K higher than before June 2014.

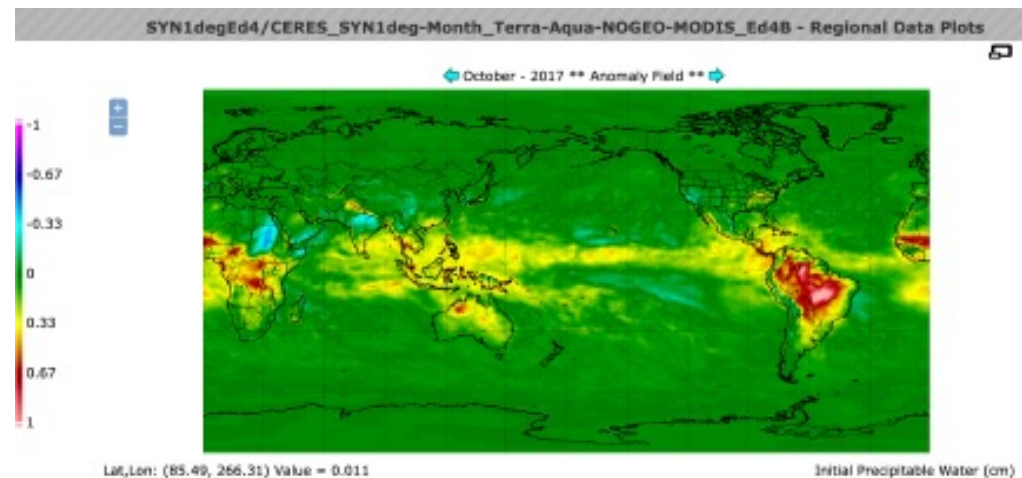
Impact of Increasing surface temperature to water vapor amount

- Clausius-Clapeyron equation predicts about a 7% increase in water vapor for each 1 K increase in temperature for a typical lower troposphere condition (Held and Soden 2006).
- Changing relative humidity is small and has a minor impact on water vapor change (O'Gorman and Muller 2010).
- MERRA-2 skin temperature after July 2014 (post hiatus) is 0.29K higher than before June 2014.
- If air temperature increases by a similar magnitude as the skin temperature, a 0.29 K change in skin temperature increases precipitable water by ~2%.

Global mean precipitable water anomalies



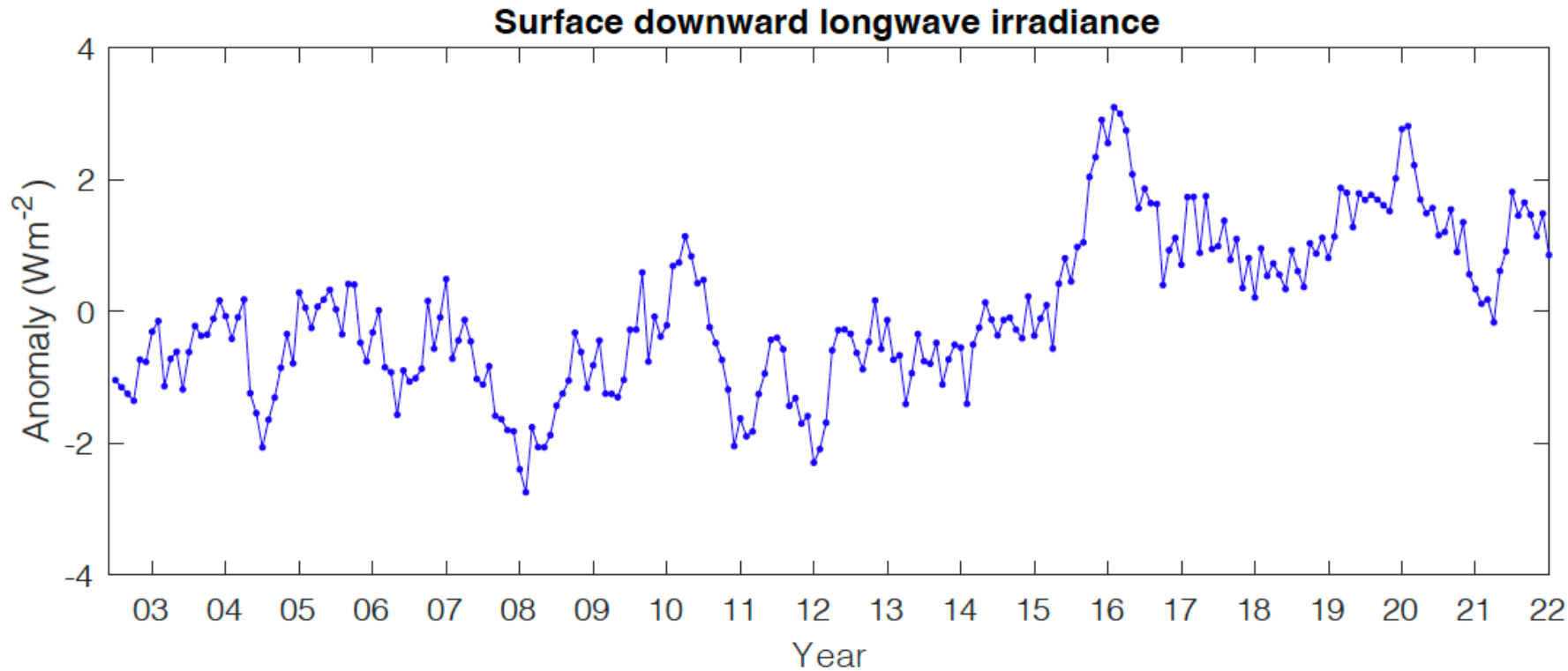
MERRA-2 – GEOS-5.4.1
Regional precipitable water
difference for October 2017



Global mean precipitable water is
2.56 cm.

In Merra-2, Precipitable water
increased y 0.05 cm after July 2014,
which is a ~2% increase.

Global clear-sky surface downward longwave irradiance anomaly (computed with MERRA-2)



Clear-sky downward longwave increased by 1.9 Wm^{-2}

A 0.29 K change in lower troposphere (below 500 hPa) increases the downward longwave by 1.2 Wm^{-2}

A 2% increase in precipitable water increases the downward longwave by 1.3 Wm^{-2} .

Clear-sky downward irradiance change is corresponding temperature and water vapor change

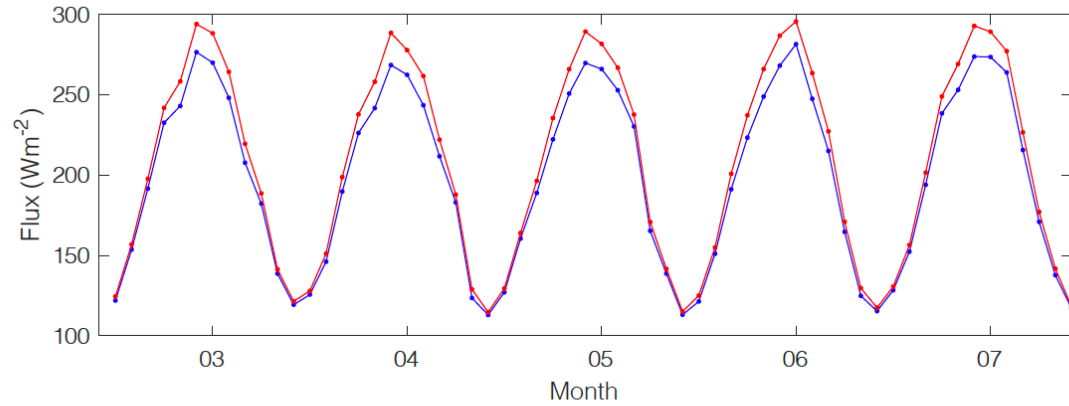
Publications

- Ham, S.-H., S. Kato, F. G. Rose, N. G. Loeb, K.-M. Xu, T. Thorsen, M. G. Bosilovich, S. Sun-Mack, Y. Chen, and W. F. Miller, 2021: Examining Cloud Macrophysical Changes over the Pacific for 2007–17 Using CALIPSO, CloudSat, and MODIS Observations, *J. Appl. Meteo. Clim.*, 60(8), 1105-1126, DOI: 10.1175/JAMC-D-20-0226.1.
- Fillmore, D. W., D. A. Rutan, S. Kato, F. G. Rose, and T. E. Caldwell, 2021: Evaluation of aerosol optical depths and clear-sky radiative fluxes of the CERES Edition 4.1 SYN1deg data product, submitted to *Atmospheric Chemistry and Physics*.
- Ham, S. H., S. Kato, F. G. Rose, S. Sun-Mack, Y. Chen, W. F. Miller, and R. Scott, 2022: Combining cloud properties from CALIPSO, CloudSat, and MODIS for top-of-atmosphere (TOA) SW broadband irradiance computations: impact of cloud vertical profiles, submitted to *J. Applied Meteorology and Climatology*.
- Scott, R. C., F. G. Rose, P. W. Stackhouse Jr., N. G. Loeb, S. Kato, D. R. Doelling, D. A. Rutan, and P. C. Tayler, 2022: Clouds and the Earth's Radiant Energy System (CERES) Cloud Radiative Swath (CRS) Edition 4 data product, submitted to *Journal of Atmospheric and Oceanic Technology*.

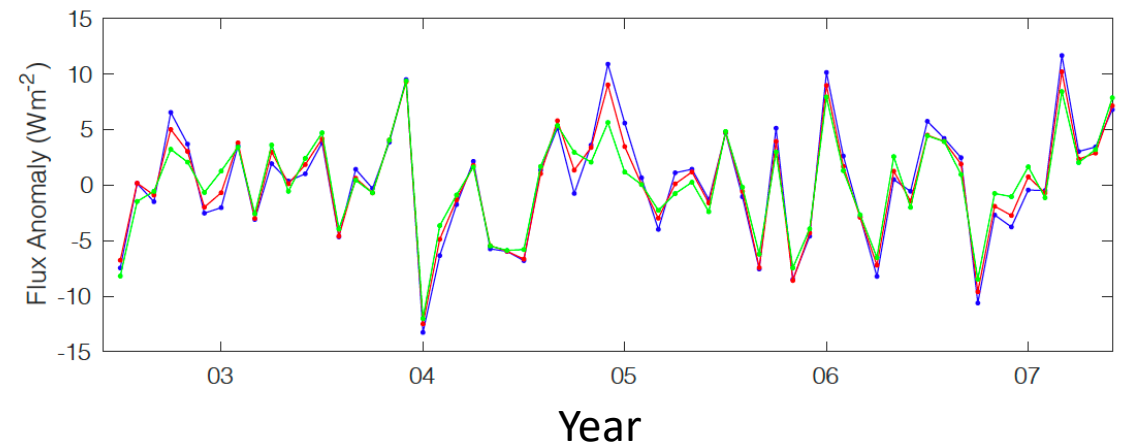
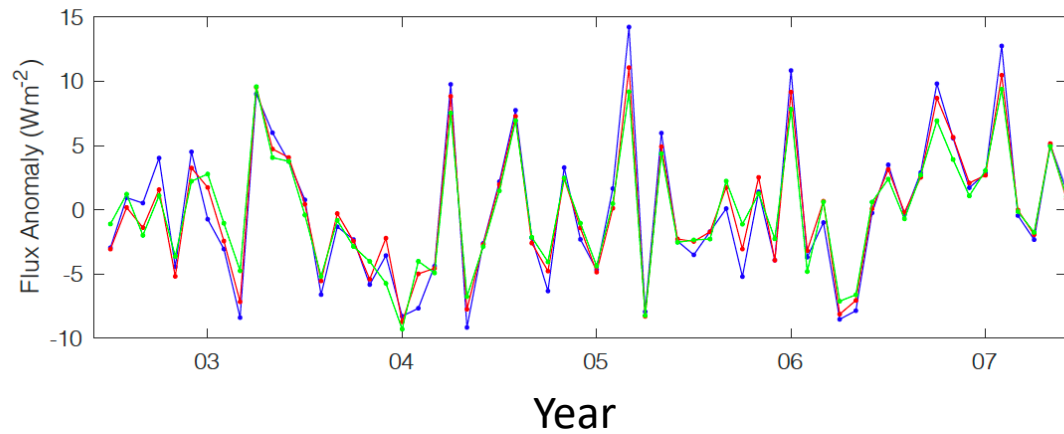
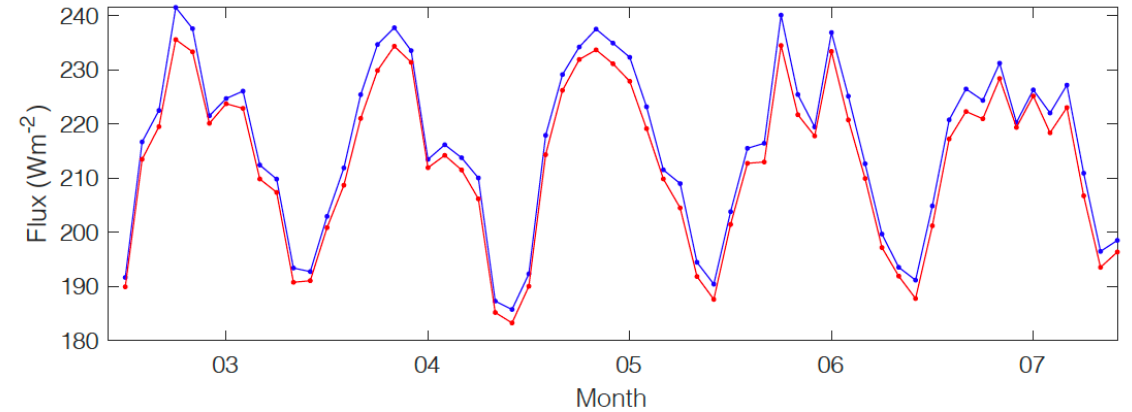
Regional anomaly time series, downward shortwave

Blue: Terra only, Red: Terra+Aqua, Green Aqua only

Southeastern Pacific (Lat 15:35, Lon 270:290)

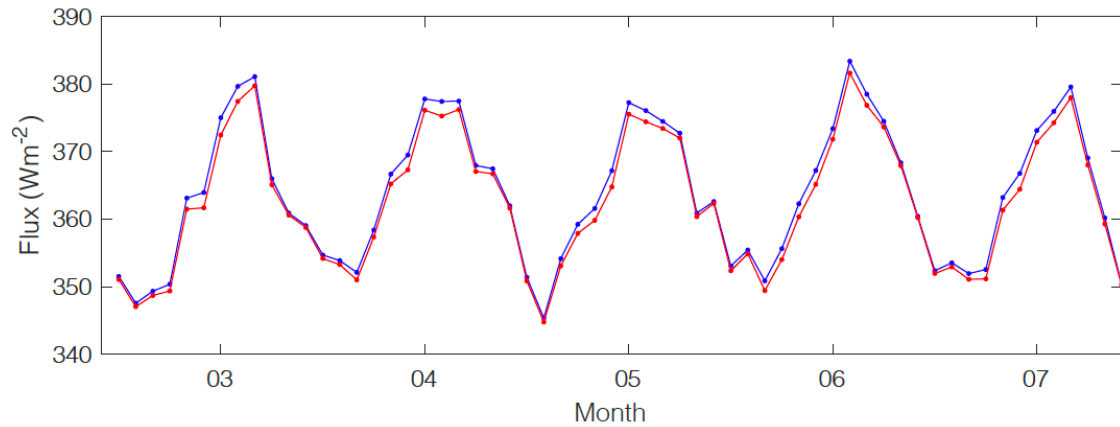


Tropical South America (Lat 0:20, Lon 315:345)

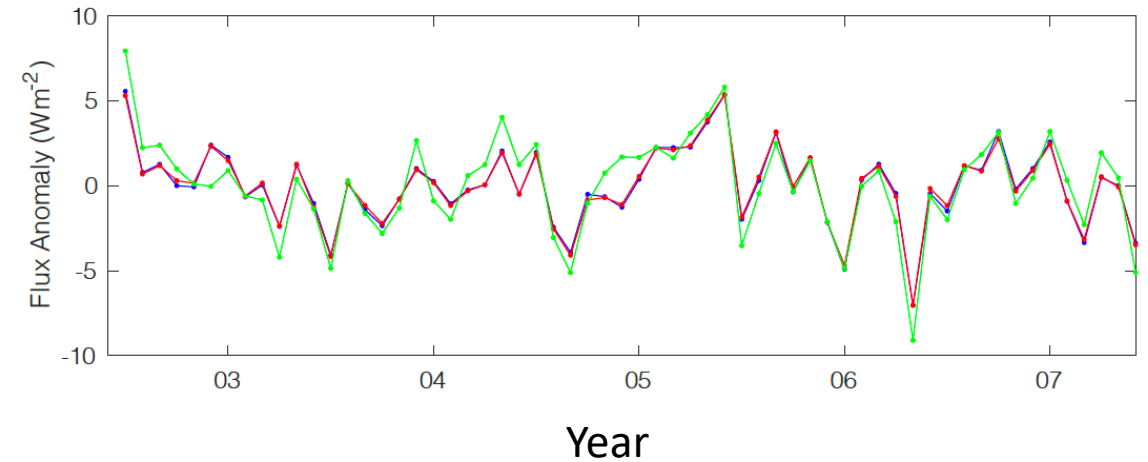
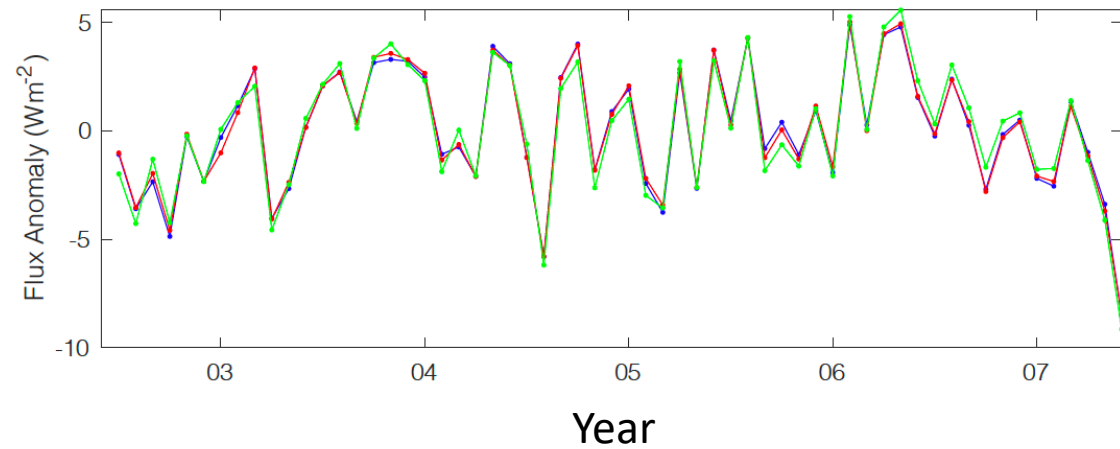
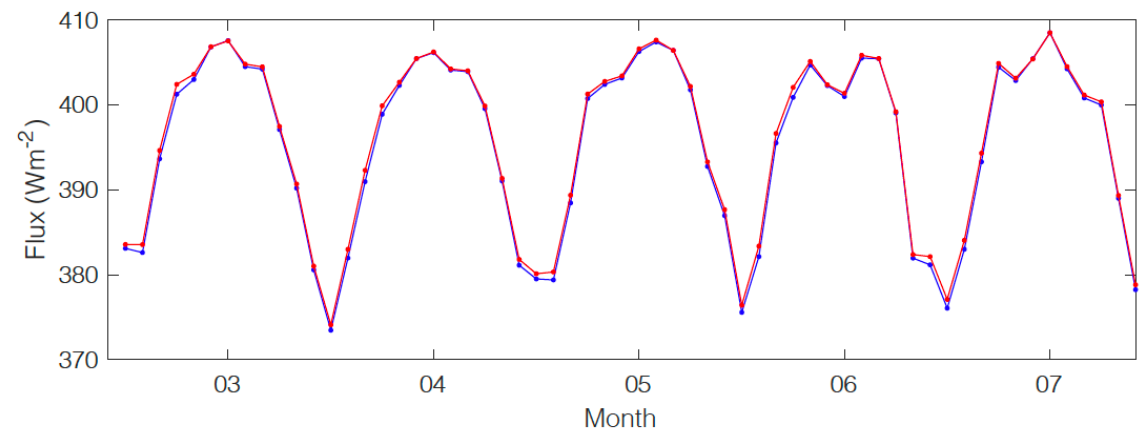


Regional anomaly time series, downward longwave

Southeastern Pacific (Lat 15:35, Lon 270:290)



Tropical South America (Lat 0:20, Lon 315:345)



Blue: Terra only, Red: Terra+Aqua, Green Aqua only

Aqua only was produced with GEOS-5.4.1